

Figure 1

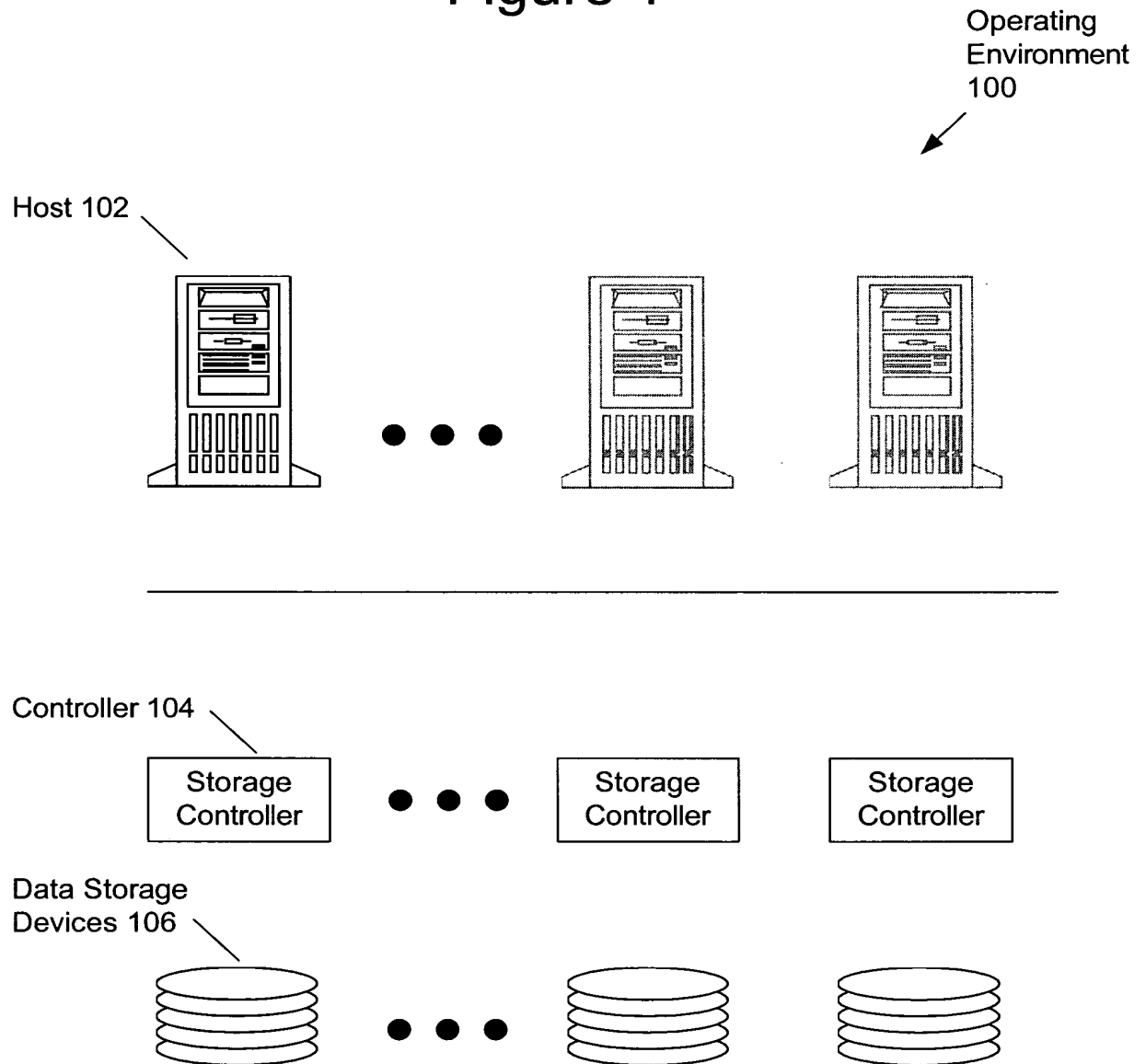


Figure 2

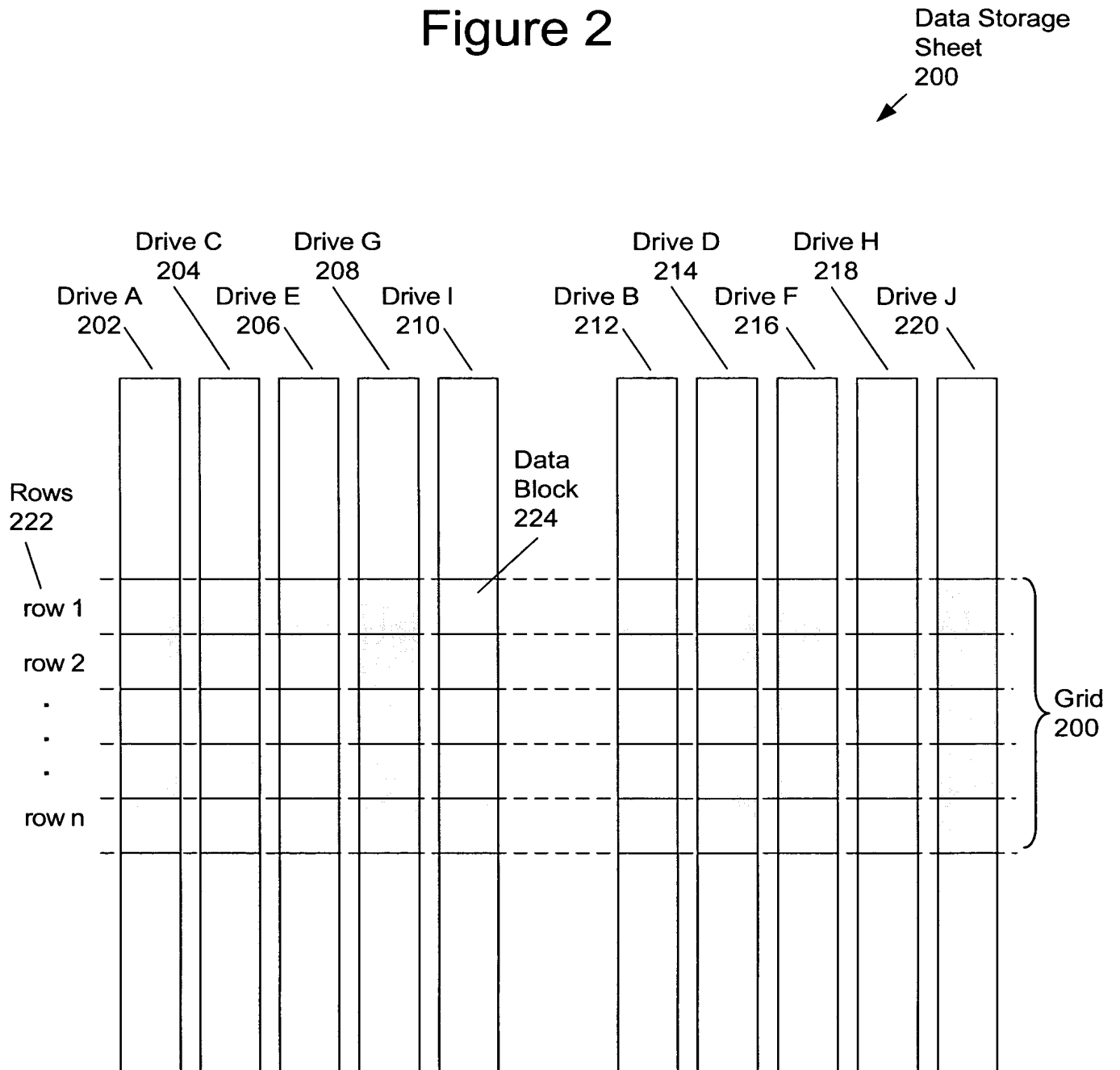


Figure 3

Sparing
Table
300



304 Sparing Versions

302 Drives

Version \ Drives	Group 1 Drives					Group 2 Drives					
	A	C	E	G	I		B	D	F	H	J
SV1	u	u	u	u	s		u	u	u	u	s
SV2	u	u	u	s	u		u	u	u	s	u
SV3	u	u	s	u	u		u	u	s	u	u
SV4	u	s	u	u	u		u	s	u	u	u
SV5	s	u	u	u	u		s	u	u	u	u

Group 1 Drives
306

Group 2 Drives
308

Figure 4A

Chapter
Table
400
↙

Paragraphs 402 ↘	Group 1 Drives 404 ↘	Group 2 Drives 406 ↘	Spare Drives 408 ↘
Paragraph	Group 1	Group 2	Spare
1	A C E G	B D F H	I J
2	C E G I	D F H J	A B
3	G A I E	H B J F	C D
4	A I G C	B J H D	E F
5	E A C I	F B D J	G H

Figure 4B

Capacity
Grid
410
↙

Group 1 412				Group 2 414			
A	C	E	G	B	D	F	H
A	C	E	G	B	D	F	H
A	C	E	G	B	D	F	H
A	C	E	G	B	D	F	H
A	C	E	G	D	D	F	H

Figure 5A

Single Row
RAID-0 Grid
500

Data A-1	Data A-2	Data A-3	Data A-4	Data B-1	Data B-2	Data B-3	Data B-4
-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------

Figure 5B

Two Row
RAID-0 Grid
502

Data A-1	Data A-2	Data A-3	Data A-4	Data B-1	Data B-2	Data B-3	Data B-4
Data C-1	Data C-2	Data C-3	Data C-4	Data D-1	Data D-2	Data D-3	Data D-4

Figure 5C

Five Row
RAID-0 Grid
504

Data A-1	Data A-2	Data A-3	Data A-4	Data B-1	Data B-2	Data B-3	Data B-4
Data C-1	Data C-2	Data C-3	Data C-4	Data D-1	Data D-2	Data D-3	Data D-4
Data E-1	Data E-2	Data E-3	Data E-4	Data F-1	Data F-2	Data F-3	Data F-4
Data G-1	Data G-2	Data G-3	Data G-4	Data H-1	Data H-2	Data H-3	Data H-4
Data I-1	Data I-2	Data I-3	Data I-4	Data J-1	Data J-2	Data J-3	Data J-4

Figure 6A

Single Row
RAID-1 Grid
600

Data A-1	Data A-2	Data A-3	Data A-4	Data A-1	Data A-2	Data A-3	Data A-4
-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------

Figure 6B

Two Row
RAID-1 Grid
602

Data A-1	Data A-2	Data A-3	Data A-4	Data B-1	Data B-2	Data B-3	Data B-4
Data B-1	Data B-2	Data B-3	Data B-4	Data A-1	Data A-2	Data A-3	Data A-4

Figure 6C

Five Row
RAID-1 Grid
604

Data A-1	Data A-2	Data A-3	Data A-4	Data B-1	Data B-2	Data B-3	Data B-4
Data C-1	Data C-2	Data C-3	Data C-4	Data D-1	Data D-2	Data D-3	Data D-4
Data E-1	Data E-2	Data E-3	Data E-4	Data A-1	Data A-2	Data A-3	Data A-4
Data B-1	Data B-2	Data B-3	Data B-4	Data C-1	Data C-2	Data C-3	Data C-4
Data D-1	Data D-2	Data D-3	Data D-4	Data E-1	Data E-2	Data E-3	Data E-4

Figure 7

RAID-5
Grid
700



Data A-1	Data A-2	Data A-3	Data A-4	Data B-1	Data B-2	Data B-3	Data B-4
Data C-1	Data C-2	Data C-3	Data C-4	Data D-1	Data D-2	Data D-3	Data D-4
Data E-1	Data E-2	Data E-3	Data E-4	Data F-1	Data F-2	Data F-3	Data F-4
Data G-1	Data G-2	Data G-3	Data G-4	Data H-1	Data H-2	Data H-3	Data H-4
PB	PD	PF	PH	PA	PC	PE	PG

Figure 8A

A	A	A	A	B	B	B	B
C	C	C	C	D	D	D	D
E	E	E	E	F	F	F	F
G	G	G	G	H	H	H	H
I	I	I	I	J	J	J	J

RAID-0
Grid
800



Figure 8B

A	A	A	A	B	B	B	B
C	C	C	C	D	D	D	D
E	E	E	E	A	A	A	A
B	B	B	B	C	C	C	C
D	D	D	D	E	E	E	E

RAID-1
Grid
802



Figure 8C

A	A	A	A	B	B	B	B
C	C	C	C	D	D	D	D
E	E	E	E	F	F	F	F
G	G	G	G	H	H	H	H
PB	PD	PF	PH	PA	PC	PE	PG

RAID-5
Grid
804



Figure 9A

A	A	A	A	B	B	B	B
C	C	C	C	D	D	D	D
E	E	E	E				
G	G	G	G				

RAID-0
Grid
900



Figure 9B

A	A	A	A	B	B	B	B
C	C	C	C	D	D	D	D
E	E	E	E	A	A	A	A
B	B	B	B	C	C	C	C
D	D	D	D	E	E	E	E

RAID-1
Grid
902



Figure 9C

A	A	A	A	B	B	B	B
C	C	C	C	D	D	D	D
E	E	E	E				
PB	PD			PA	PC	PE	

RAID-5
Grid
904



RAID 6
Capacity Grid
1000

Data Sets

Figure 10B

RAID 6
Data / Parity
Map
1002
↙

Data Blocks 1004	A-1	A-2	A-3	A-4	E-5	E-6	E-7	E-8		Data 1
	B-8	B-1	B-2	B-3	F-4	F-5	F-6	F-7		
	C-7	C-8	C-1	C-2	G-3	G-4	G-5	G-6		
	D-6	D-7	D-8	D-1	H-2	H-3	H-4	H-5		
	I-10	I-9	I-12	I-11	M-14	M-13	M-16	M-15		
	J-9	J-16	J-11	J-10	N-13	N-12	N-15	N-14		
	K-16	K-15	K-10	K-9	O-12	O-11	O-14	O-13		
	L-15	L-14	L-9	L-16	P-11	P-10	P-13	P-12		
Parity Blocks 1006	13P	5P	15P	7P	9P	1P	11P	3P		Vertical Parity (VPAR-1)
	14P	6P	16P	8P	10P	2P	12P	4P		Row Parity (RPAR-1)
	EP	MP	FP	NP	AP	IP	BP	JP		
	GP	OP	HP	PP	CP	KP	DP	LP		

Grid Contents
1008

Figure 11

RAID 6
DSU / Parity
Map
1100

Failed Drives
1102

A-1	A-2
B-8	B-1
C-7	C-8
D-6	D-7
I-10	I-9
J-9	J-16
K-16	K-15
L-15	L-14
13P	5P
14P	6P
EP	MP
GP	OP

Inaccessible
Blocks
1108

A-3	A-4	E-5	E-6	E-7	E-8
B-2	B-3	F-4	F-5	F-6	F-7
C-1	C-2	G-3	G-4	G-5	G-6
D-8	D-1	H-2	H-3	H-4	H-5
I-12	I-11	M-14	M-13	M-16	M-15
J-11	J-10	N-13	N-12	N-15	N-14
K-10	K-9	O-12	O-11	O-14	O-13
L-9	L-16	P-11	P-10	P-13	P-12
15P	7P	9P	1P	11P	3P
16P	8P	10P	2P	12P	4P
FP	NP	AP	IP	BP	JP
HP	PP	CP	KP	DP	LP

Accessible
Blocks
1110

Data
Blocks
1104

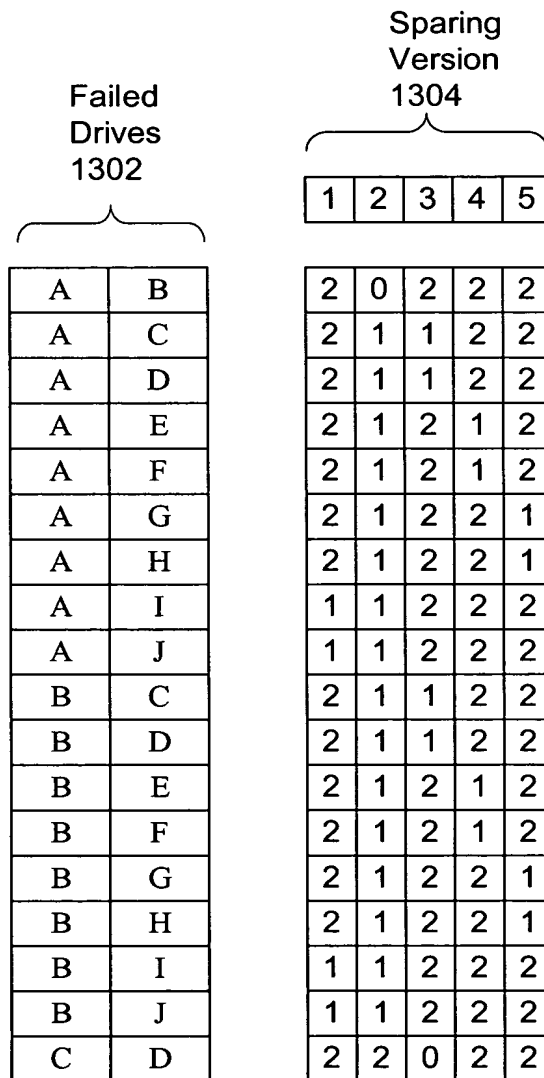
Parity
Blocks
1106

Figure 12


RAID 6
Reconstruction
Example
1200

Steps 1202	Regenerated Blocks 1204	Calculations 1206							
Step 1	A-2	=	B-2	XOR	C-2	XOR	H-2	XOR	2P
	I-10	=	J-10	XOR	K-10	XOR	P-10	XOR	10P
	13P	=	M-13	XOR	N-13	XOR	O-13	XOR	P-13
	5P	=	E-5	XOR	F-5	XOR	G-5	XOR	H-5
	EP	=	E-5	XOR	E-6	XOR	E-7	XOR	E-8
	MP	=	M-14	XOR	M-13	XOR	M-16	XOR	M-15
	GP	=	G-3	XOR	G-4	XOR	G-5	XOR	G-6
	OP	=	O-12	XOR	O-11	XOR	O-14	XOR	O-13
Step 2	A-1	=	A-2	XOR	A-3	XOR	A-4	XOR	AP
	I-9	=	I-10	XOR	I-12	XOR	I-11	XOR	IP
Step 3	B-1	=	A-1	XOR	C-1	XOR	D-1	XOR	1P
	J-9	=	I-9	XOR	K-9	XOR	L-9	XOR	9P
Step 4	B-8	=	B-1	XOR	B-2	XOR	B-3	XOR	2P
	J-16	=	J-9	XOR	J-13	XOR	J-10	XOR	JP
Step 5	C-8	=	B-8	XOR	D-8	XOR	E-8	XOR	8P
	K-16	=	J-16	XOR	M-16	XOR	L-16	XOR	15P
Step 6	C-7	=	C-8	XOR	C-1	XOR	C-2	XOR	CP
	K-15	=	K-16	XOR	K-10	XOR	K-9	XOR	KP
Step 7	D-7	=	C-7	XOR	E-7	XOR	F-7	XOR	7P
	L-15	=	K-15	XOR	M-15	XOR	N-15	XOR	15P
Step 8	D-6	=	D-7	XOR	D-8	XOR	D-1	XOR	DP
	L-14	=	L-15	XOR	L-9	XOR	L-16	XOR	LP
Step 9	6P	=	D-5	XOR	E-6	XOR	F-6	XOR	G-6
	14P	=	L-14	XOR	M-14	XOR	N-14	XOR	O-14

Figure 13



Capacity Grid
Failed Drives
with Sparing
1300



Failed Columns
Within a Capacity
Grid
1306

Figure 14A

Chapter
Table
1400



Paragraph	Group 1	Group 2	Spare
1	A C E G	B D F H	I J
2	C E G I	D F H J	A B
3	G A I E	H B J F	C D
4	A I G C	B J H D	E F
5	E A C I	F B D J	G H

Figure 14B

Singly Spared
Table
1402



Sparing Version	Group 1	Group 2	Spare
1	I C E G	B D F H	J
2	C E G I	D F H J	B
3	G C I E	H B J F	D
4	E I G C	B J H D	F
5	E G C I	D F H J	H

Figure 14C

Singly Spared
Paired Table
1404

Paragraph	Group 1	Group 2	Spare
1	I C E G	J D F H	
2	C E G I	D F H J	
3	G C I E	H D J F	
4	E I G C	F J H D	
5	E G C I	F H D J	

Figure 14D

Doubly Spared
Chapter Table
1406

Paragraph	Group 1	Group 2	Spare
1	I J E G	B D F H	
2	B E G I	D F H J	
3	G D I E	H B J F	
4	E I G F	B J H D	
5	E G H I	F B D J	

Figure 15

Steps for Sparing
in a Data Grid
1500

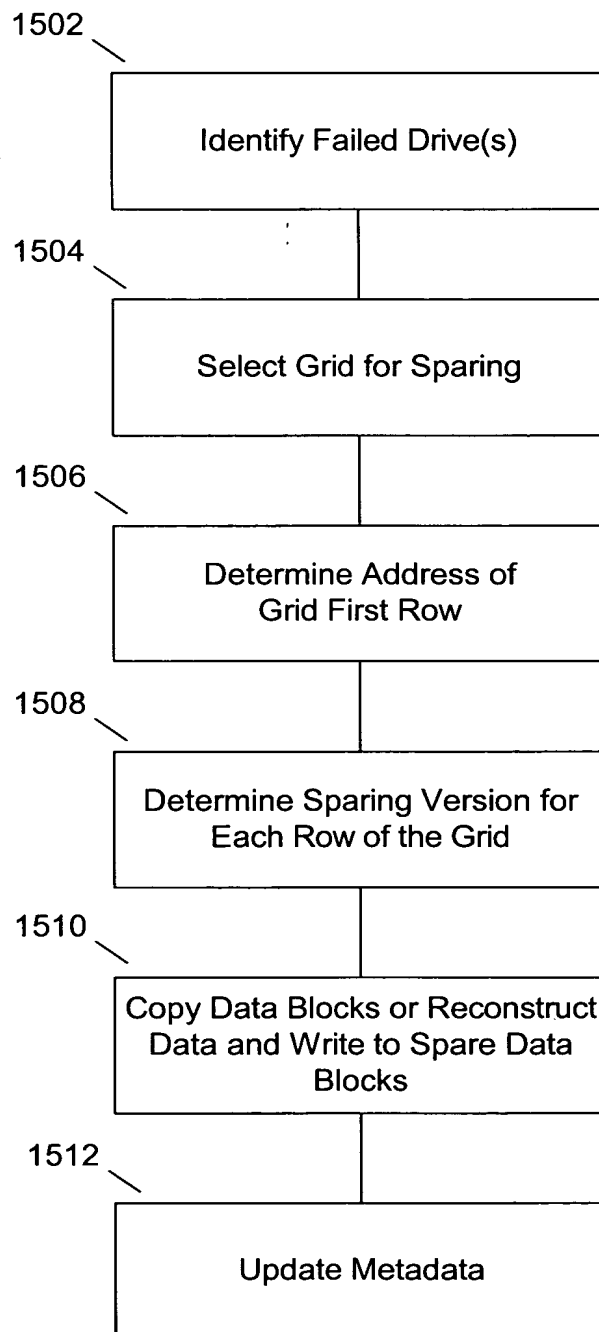


Figure 16

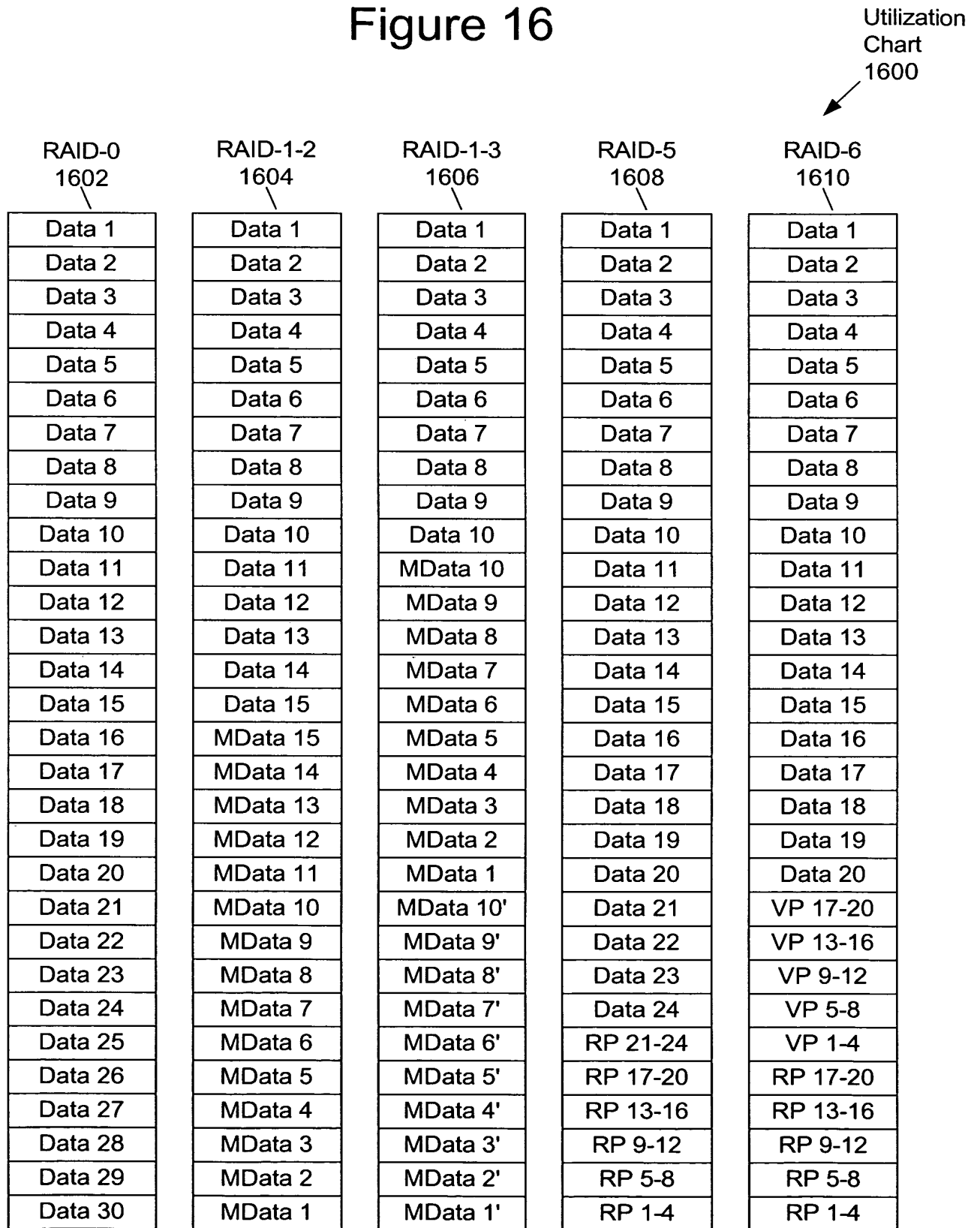


Figure 17

Steps to convert
a grid from one
format to another
1700

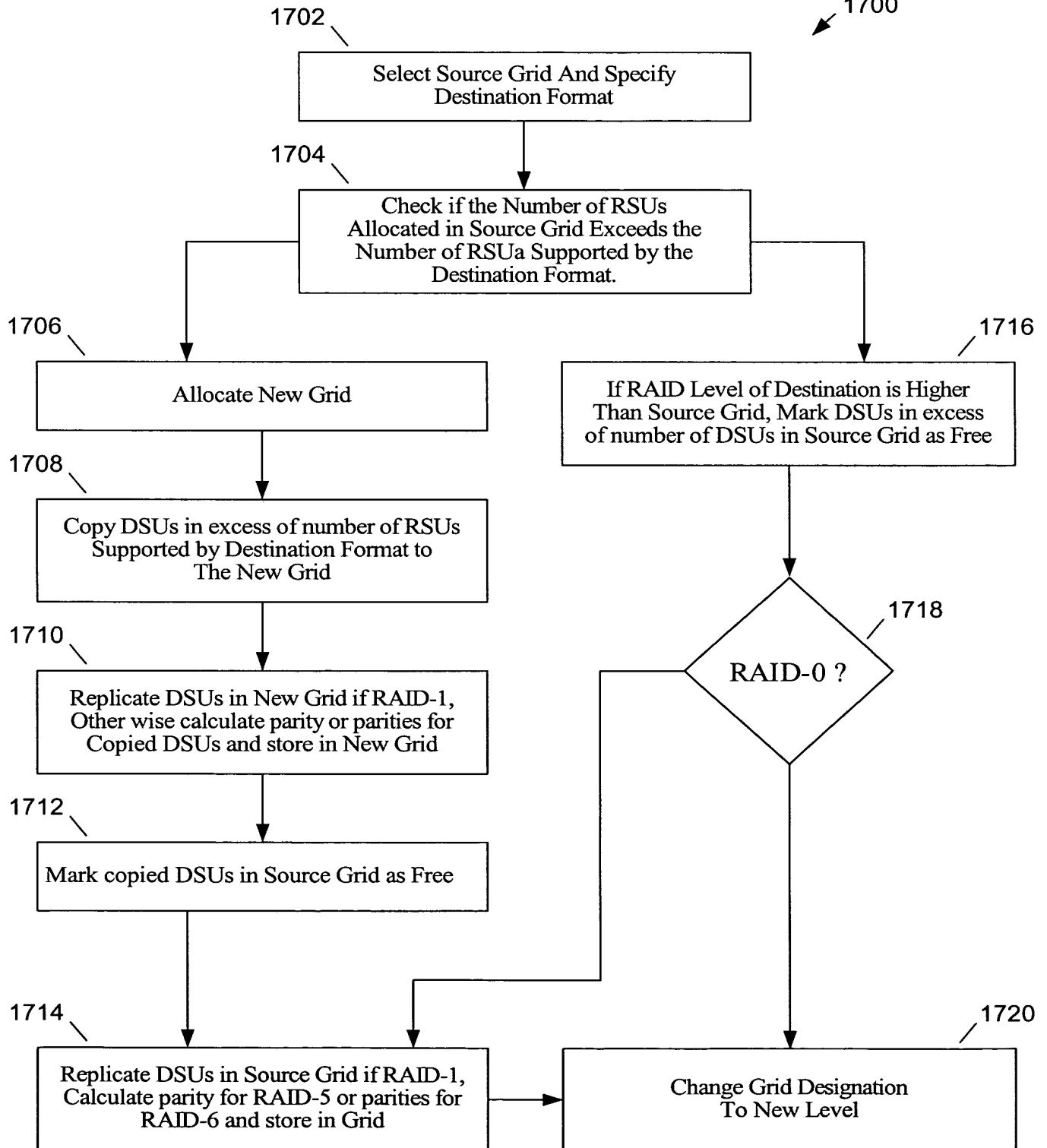


Figure 18

Steps to Configure
a system to use
a Data Grid
1800

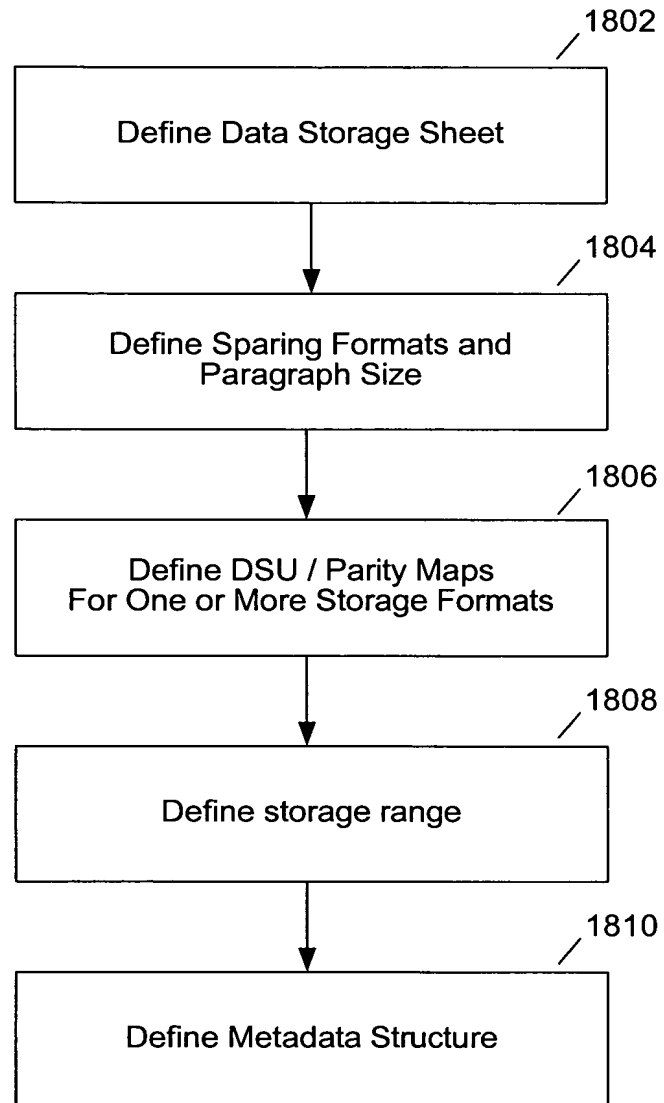


Figure 19

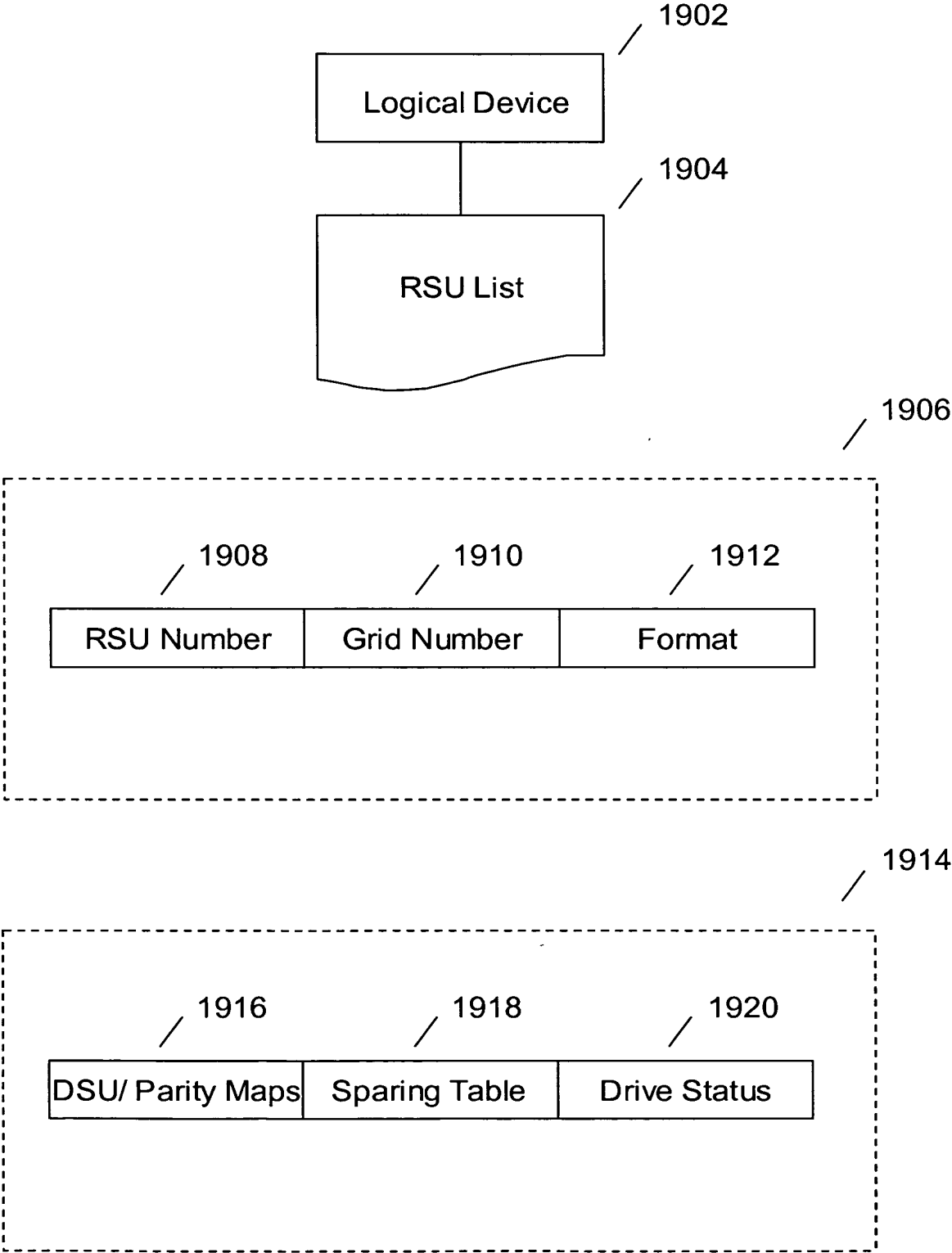


Figure 20

Steps to Access
Data Using a
Data Grid
2000

